Weight contributions of stomach compartment and organs to body weight of Mongolian gazelles

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Abstract The stomach compartments of 51 Mongolian gazelles (*Procapra guttrurosa*) were weighed and the data were compared with total body weight. The total tissue weights ranged from 2.70% to 2.82% of body weight. Rumens were the heaviest, occupying about 75% of the total stomach, followed by reticulums (9%~11%), abomasums (8%~10%) and omasums (4%~6%). The weights of rumens were directly proportional to body weights and weights of omasums and abomasums were inversely related to body weights. Stomachs of the Mongolian gazelle were of the "mixed feeder" in terms of total weight and contribution of each compartment.

Key words: *Procapra guttrurosa*, Stomach compartment, Body weight

Introduction

Of all mammals, the ruminants have the most differentiated, specialized and complex stomachs, which appear to be the best suited for digesting and utilizing feed rich in cellulose. Hofmann (1972) stated that the ruminant stomach was structurally adapted to utilize certain distinct types of food after comprehensively compared the stomach-structure of 26 of 31 eastern African ruminants. According to their stomach-structure and food feature, these ruminants may be grouped into three main types of feeder: a) bulk and roughage eaters (grazers); b) selectors of juicy, concentrated herbage (browsers); c) intermediate feeders, which can adapt at different seasons or in different areas towards type of a) or b). Briefly, bulk and roughage eaters have in common a subdivided, capacious rumen, which permits the maximum delay of coarse, fibrous feed. All selectors of juicy, concentrated herbage have a relatively small, simple rumen (a folded tube), which adapts to a quick turnover of food and a high fermentation rate; the intermediate feeders are intermediate with regard both to their feeding habits and to the morphological features described above. In other word, relationships between body size and diet quality of ruminants indicate that smaller ruminants (concentrate selectors) prefer more nutritious food than larger ones because they require relatively more energy than larger ruminants (roughage eaters). Geist (1974) referred to this concept as the Jarman-Bell Principle (Bell 1971; Jarman 1974). It also stated that roughage eaters must have relatively larger rumen that adequately retain and digest roughage-type feed. The principle has been studied only in African and North American animals. There were a few data obtained in Asia (Seiki T. 1988).

Mongolian gazelles (*Procapra guttrurosa*) are an important wild ruminant in eastern Inner Mongolian Grassland. It used to be the most numerous and an important component of the grassland ecosystem. However, the population is now decreasing and facing extinction in China. Therefore, it is very important to construct the conservation program. Thus the nutritional ecology study on Mongolian gazelles should be an important part of the program. The objective of our study was to report the stomach weight of Mongolian gazelles in relation to body weight and to evaluate their anatomical adaptations relative to a grazer-browser gradient. We clarify the position of Mongolian gazelles along this gradient by comparing the relative weight of total stomach to body weight and the contribution of each compartment to stomach weight in other ruminant species.

Materials and methods

Mongolian gazelles were shot by hunters during the winter, spring, and fall of 1997~1998. Immediately

Received: 1999-03-18
Responsible editor: Zhu Hong

after death, body weights were determined to the nearest 0.5 kg with a spring scale. Then the animals were opened and all internal organs removed (tongue, esophagus, trachea, lungs, heart, kidneys, and the entire digestive tract). Each organ was weighed and then subtracted from the total body weight to be obtained the carcass weight. Blood and urine were not collected, so carcass weights were slightly high. Each compartment of the stomach with its contents was separated and weighed to the nearest 0.1 g with an electronic scale (Yamaha ZD300, made in Japan). After emptying the contents and removing fat tissues, the stomach tissues were washed, blotted dry with towels, and again weighed to the nearest 0.1 g. Data were grounded by sex as well as adults (> 1.5 years old) or fawns (< 1.5 years old). Age class was determined on the basis of tooth replacement and wear technique (Jingo *et al.* 1993). The data statistics were regressed separately against body weight. In all cases, $P< 0.05$ level was used for test of significance.

Study areas

The study site situates in Xiqi southwestern Hulunberer grassland (115°00'~117°48'E, 47°39'~ 49°50'N), with average elevation above 600 m and rolling surface. The highest part is Bain Mountain (1 038 m), while the lowest is 540 m around Dalai Lake (2 200 km^2). Because the Daxing'an Mountains prevent moist winds from the ocean, the climate is featured semiarid. Average annual temperature is as low as -3~0°C, -40°C for the lowest and 35~40°C for the highest. The frost-free period is 80~120 d, and perpetual snow period 120~180 d. The annual precipitation was ranged 250~380 mm of which 70 percent happen in summer. The annual evaporation is 1 300 ~1 900 mm.

The vegetation belongs to the cool temperate tall grassland. The grasslands are categorized into five types according to the species composition: the *Stipa grandis-Aneurolepidium chinense* type, the *Stipa grandis-Cleistogenes squarrosa* type, the *Cleistogenes squarrosa-Lespedeza spp*. type, the *Artemisia frigida* type, and the *Aneurolepidium chinense -Stipa grandis*-Herbs type (Hu *et al.* 1992). About 200 bird species and 20 mammalian species were recorded in the area. Mongolian gazelles is a medial size ungulate in the ecosystem with high economic values.

Results

Some stomach characteristics of the 51 Mongolian gazelles necropsied in this study are listed in Table 1. Rumens (75.74%) were the heaviest compartment, followed by reticulums (9.82%), abomasums (8.93%), and omasums (5.40%), except for fawn females of which abomasums were larger than reticulums. Relative weights of the stomach compartments tissue were not significantly different among individuals, but the contribution of the rumen to total stomach weight was the largest in adult males, followed by fawn males, adult females and fawn females. The contribution of abomasums was the largest in fawn females, followed by adult males, fawn males, and adult females. The contribution of reticulums was the largest in adult females, followed by fawn males, fawn females, and adult males. The contribution of omasums was the smallest in fawn males, followed by adult males, adult females, and fawn females.

Table 1. Total body weight (BW/kg) and contribution of the rumen (Rm), reticulum (Rt), omasum (Om), and abomasum (Ab) to the total stomach weight of Mongolian gazelle collected in China during 1997~1998.

Item		Fawn number	Mean value /%	SD	Adult number	Mean value /%	SD
Male	BW	14	19.79	3.16	16	26.45	1.50
	Rm	14	76.03	3.23	16	76.17	2.85
	Rt	14	9.68	2.48	16	9.55	2.05
	Om	14	5.29	0.97	16	5.31	1.02
	Ab	14	8.90	1.15	16	8.97	1.17
Female	BW	10	16.42	1.94	11	21.44	2.14
	Rm	10	72.68	4.85	11	75.42	2.72
	Rt	10	9.60	0.86	11	10.19	1.87
	Om	10	5.98	0.42	11	5.74	0.70
	Ab	10	10.61	1.34	11	8.69	1.41

Table 1 also showed that relative weight of the compartments was changed as the body weight differed significantly between sexes or age classes within all specimens. The relative weight of the rumen increased in proportion to body weight. This relationship was most pronounced in females (r = 0.902 0, P > 0.05) with an upper limit around 78.60%, but was relatively smaller in males (r = 0.791 9, P > 0.05). Except for rumens, however, relative omasums and abomasums weight declined linearly as body weight

increased. The relative weight of the reticulum was constant for males and females. The equations for the linear regression of rumen, reticulum, omasum, and abomasum are shown in Table 2.

Table 2. The equations of the linear regression relation between the contribution of the compartments (*y*) and body weight (*x*) of Mongolian gazelle

Compartment	Equation of the regression			
Rumen	$y = 67.95 + 0.34x$	$r = 0.5162$	$F = 17.99^{**}$	$P > 0.05$
Reticulum	$y = 13.49 + 0.16x$	$r = -0.3380$	$F = 6.31^{*}$	$P > 0.05$
Omasum	$y = 6.90 + 0.06x$	$r = -0.5006$	$F = 23.72^{**}$	$P > 0.05$
Abomasum	$y = 11.90 + 0.12x$	$r = -0.4326$	$F = 11.28^{**}$	$P > 0.05$

Note: * (**) -- The correlation is significant (very significant).

The entire weight of the stomach tissue was about 2.74 (SD=0.14, n=16, P>0.05), 2.82 (SD=0.14, n=14, P>0.05), 2.83 (SD=0.09, n=10, P>0.05), and 2.89 (SD=0.20, n=11, P>0.05) percent of the body weight in adult males, fawn males, adult females, and fawn females, respectively. Their average ratio was 2.82 (SD=0.11, n=51, P>0.05). Ruminoreticular contents averaged 10.97 (SD=1.86, P>0.05) percent of body weight. The stomach contents averaged 12.94 (SD=2.11, P>0.05) percent of body weight, and this value varied seasonally. Stomach contents was about 11.72 (SD=1.15, n=15, P>0.05), 12.02 (SD=1.06, n=17, P>0.05), and 15.07 (SD=3.34, n=19, P>0.05) percent of body weight for Mongolian gazelle in spring, autumn, and winter, respectively.

Table 3 shows that the tissue weight of the rumens and the abomasums differed significantly in different seasons while reticulum and omasum changed very little.

Table 3. The change of the apartment of stomach tissue weight of Mongolian gazelle in different seasons

Apartment	April		November		February		F	P
	Mean/g	SD	Mean/g	SD	Mean/g	SD		
Rumen	499.93	41.33	416.58	37.83	450.89	36.64	3.29*	0.01
Rbeticulum	63.66	8.11	52.88	7.34	59.72	7.82	2.38	0.01
Omasum	30.07	3.07	29.83	2.87	34.68	2.70	2.83	0.05
Abomasum	58.00	5.35	44.61	4.90	57.95	4.86	7.24	0.01
Number	15		17		19			

Note:* stands for significant difference.

Discussion

Many factors, such as quantity and quality of forage, apparently influence the passage of feed through the digestive tract. But the stomach capacity, especially ruminoreticulum capacity, is very important factor of these. Because the metabolites for occurring in the rumen provide a large portion of the energy and nutrient requirements of ruminant, the capacities of the different stomach compartments of the digestive tract have important implication in the nutrition of ruminant animals. The physiological maximum capacity of the ruminoreticulum in concern with the animal's metabolic demands should determine the retention time of the food particle in the rumen. Animals with a smaller ruminoreticulum must have a higher turnover rate to secure their nutrient need, whereas animals with a large ruminoreticulum can retain ingesta for a longer time and consequently digest more fibers. This study indicates that the weight of the Mongolian gazelle's ruminoreticulum tissue is approximately 85 percent of the stomach tissue weight. The value is higher than that in Sika deer (*Cervus nippon*, 76.70%~78.60% for adult females and fawns and 84%for adult males), and other cervids (approximately 80%, Takatsuki 1988), and slightly smaller than that of the domestic cow (80%, Short 1970). This shows that diets of Mongolian gazelle include more fibers than that of these animals. This also will help to explain why the diets of Mongolian gazelle in Hulubeier plateau are dominated by graminoids (Gao Zhongxing *et al.* 1996).

The functions of the omasum and abomasum have been described by Hungate (1966). The rough papillate on the omasal leaves conduct liquid and fine food particles between the leaves of the omasum while retaining coars food particles in the rumen. These omasal leaves absorb water, short-chain fatty acids, and other soluable constituents in the food before they enter the abomasum. Our observation indicates that the proportion of the omasum in total stomach weight seems to be relative to body weight (BW) among some ruminants: 5.00% in roe deer (*Capreolus capreolus*) (BW=20.7 kg, Nagyand Regelin 1975),

10.40% in sika deer (BW=44.3 kg, Takatsuka 1988), and 9.80% in elk (*Alace alace*, Church and Hines 1978). For Mongolian gazelle (BW=21.03 kg), the mean value was 5.58%, which is close to that of roe deer.

It was also observed that the contribution of the abomasum to the total stomach of Mongolian gazelle decreases as body weight increases, which was not consistent with comparative studies of above ruminants. The percentage of the total stomach complex comprised of abomasum tissue. The contributions of abomasums are the greatest in roe deer (15.30%, Nagy and Regelin 1975) and smallest in elk (8.60%, Church and Hines 1978), The weight of abomasums of Mongolian gazelle comprised only 9.29% of the total stomach complex. The reasons for such a difference are difficult to explain. A speculative cause is that Mongolian gazelle is a medium sized ruminat species with a relatively high metabolic rate. The vegetation of its habitat is mainly composed of graminoids, which have a high fibrous content. The Mongolian gazelle feeding on graminoids will decrease the energy cost than on other plants. Thus, the major of fibers needs to digestive process happen in a big rumen.

Demment (1982) stated that the rate of change of rumen size relative to body size would determine size-specific digestive capacities for species. The percentage of total stomach tissue weight to body weight (2.74%~2.83%) of Mongolian gazelle was larger than that in mule deer (*Odocoileus hemionus*) (1.2%, Hakonson and Whicker 1971). White-tailed deer (*O. virginianus*, Short 1964), and sika deer (2.2%~2.5%, Takatsuka 1988), but slightly smaller than that in fallow deer (*Cervus dama*) and red deer (*C. elaphus*) (3.0% and 3.0%, Nagy and Kegelin 1975). The value of Mongolian gazelle is similar to that in roe deer (2.8%, Nagy and Kegelin 1975) and some domestic ruminants: about 2.7% in sheep and 2.7%~3.4% in goats (Chivers and Hladik 1980).

Hofmann (1973) discussed the relationship between body size and rumen fill. He suggested that fill weight relative to body weight was 11%~14% in large grazers, 7%~12% in medium-sized species, and below 7% in small species. The stomach content of Mongolian gazelles was about 12.94% of body weight and this value was various in different seasons (11.72% in spring, 12.02% in autumn and 15.07% in winter). According to Hofmanm's suggestion principle, Mongolian gazelle would adapt the digestive strategies as mixed feeder.

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